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Performance Assessment: University of Michigan Meta-Material-Backed Patch Antenna

by Robert Dahlstrom and Steven Weiss

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14. ABSTRACT

This report describes measurements performed on a meta-material-backed patch antenna designed and fabricated at the University of Michigan for use by CERDEC. The purpose of the measurements was to resolve inconsistencies between the performance measured at these two organizations. The antenna consists of a microstrip patch, with a broad-banding slot, backed by a reactive impedance surface. The gain and impedance characteristics of the meta-material-backed patch antenna were found to be in agreement with the values reported by the University of Michigan within the accuracy of our measurement. The antenna proves to be broadband, both in impedance and antenna pattern characteristics, and promises to be useful for many applications.

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Meta-material, patch antenna, microstrip

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Introduction

A meta-material-backed patch antenna for use at UHF was designed and fabricated under the direction of Kamal Sarabandi at the University of Michigan for use by the U.S. Army Communications-Electronics Research Development and Engineering Center. The antenna consists of a microstrip patch, with a broad-banding slot, backed by a reactive impedance surface (RIS). Because of inconsistencies between the performance measured at these two organizations, particularly the gain of the antenna, the Army Research Laboratory (ARL) Millimeter Wave Branch was asked to duplicate the antenna measurements to assist in identifying the cause of the inconsistencies.

Return Loss

The return loss, shown in figure 1, was measured using a network analyzer. Our data showed a slightly higher return than the data reported by the University of Michigan. In subsequent conversations, we found that they used a ground plane to simulate vehicle mounting while we measured it by itself, which would account for the difference.

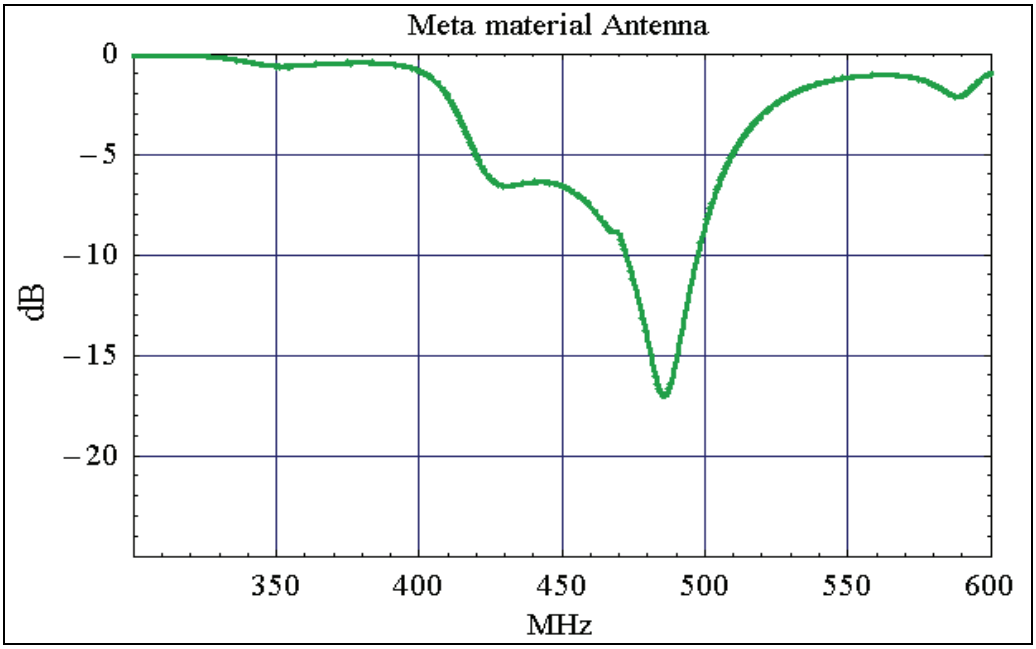

Figure 1. Measured return loss of the meta-material antenna.

Gain Measurements

The gain of the meta-material-backed patch antenna was measured in the microwave anechoic chamber at the ARL, Adelphi, MD. It was placed on a foam block oriented so that its broad face with the radiating patch was directed toward the illuminating antenna. Two reference antennas were then substituted for the antenna being tested and the received signals were measured and compared, as shown in figure 2. The realized gain curves show the gain derived by comparing the signal received by the test antenna relative to each reference and adding the estimated gain of the reference. The corrected gain curves include a correction for the impedance mismatch, as measured (above) at the connector of the meta-material-backed patch antenna, to show its gain when matched.

The primary reference antenna is the ETS-Lindgren Model 3106 horn using published typical and measured gain data. As an additional check, a Polarad UH-1 horn was used as a reference with its gain estimated based on aperture size. The different reference antennas vary in gain by about two dB but show a similar variation characteristic with frequency with gains of about 2 to 6 dB in the 420 to 485 MHz range of interest. The University of Michigan reported higher gain, particularly at the lower frequencies, but if they had used a ground plane, it could increase the gain by this amount.

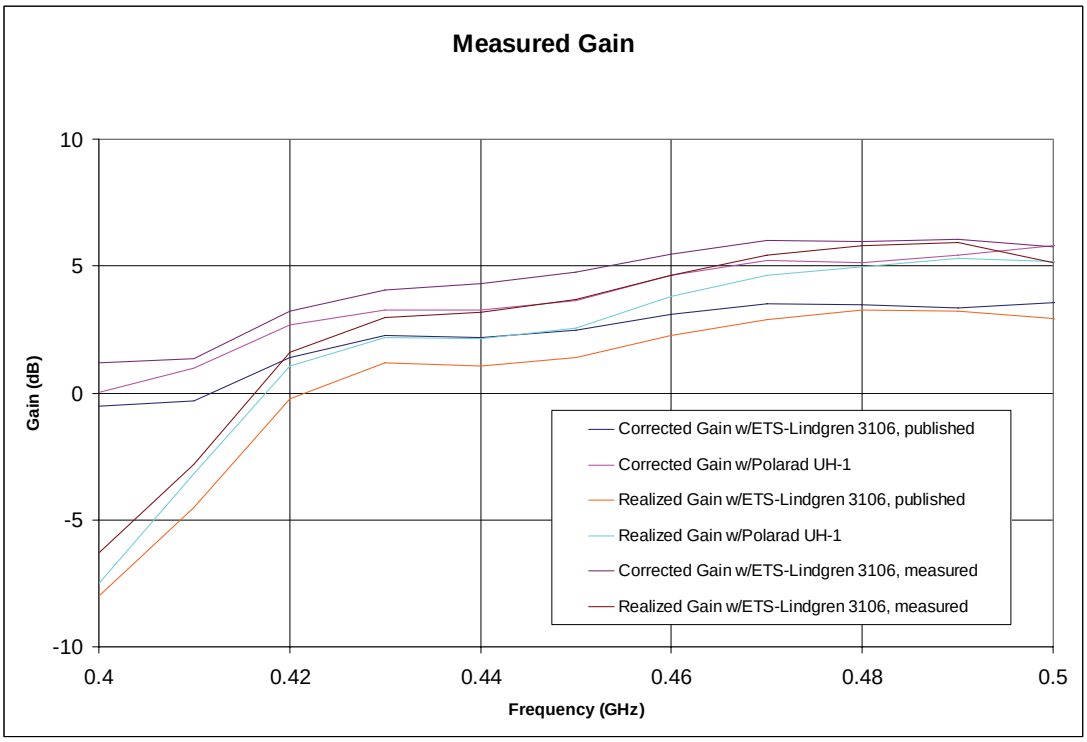

Figure 2. Measured gain of the meta-material-backed patch antenna.

Radiation Pattern Measurements

The radiation patterns of the meta-material-backed patch antenna were measured in the microwave anechoic chamber at the ARL, Adelphi, MD. The antenna was placed on a foam block on the azimuth positioner with the broad surface containing the patch facing the illuminator. Illumination was from an antenna located in the apex of the tapered chamber. The polarization was expected to be vertical with respect to the U-shaped slot based on symmetry, and a quick check verified this orientation.

The E-plane patterns are given in figure 3 and the H-plane patterns are given in figure 4. They show a broad, stable beam in each plane, slightly broader in the E-plane.

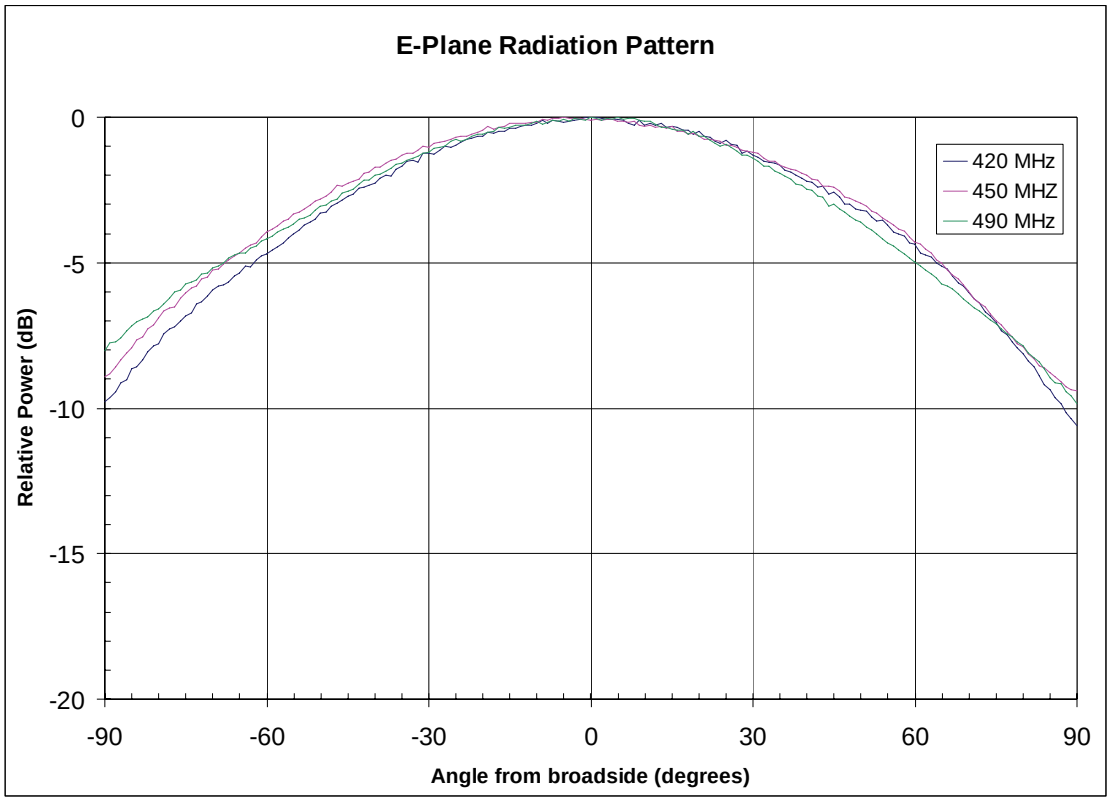

Figure 3. E-plane radiation pattern.

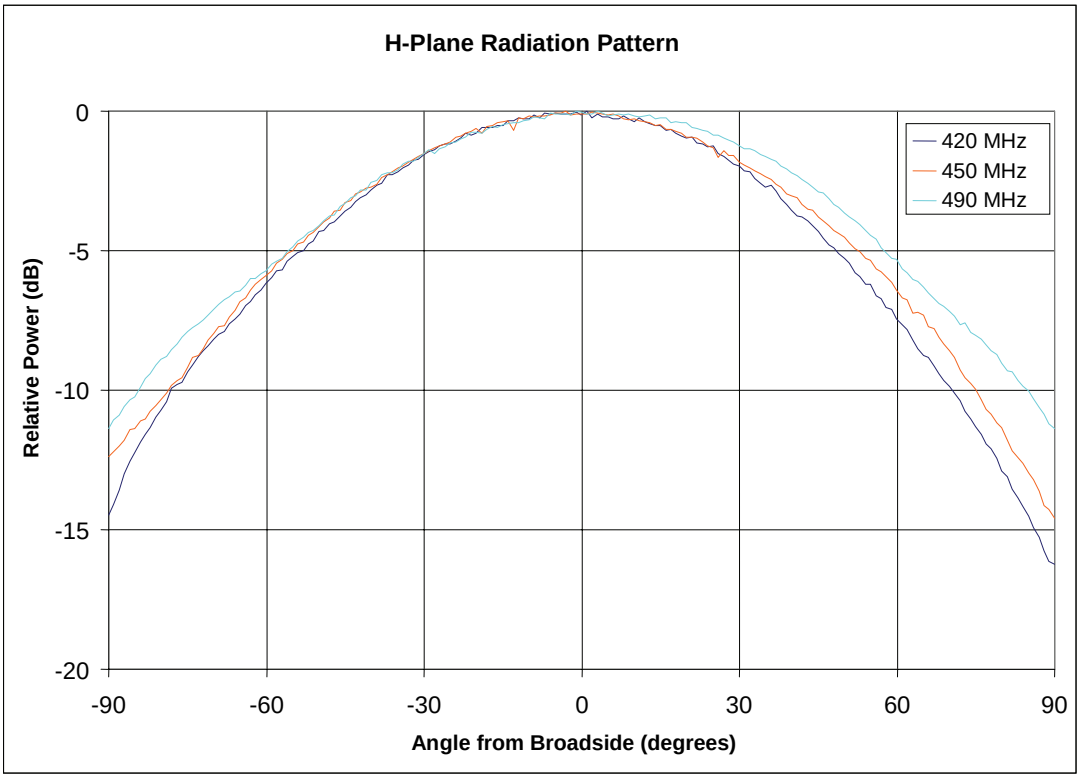

Figure 4. H-plane radiation pattern.

Summary

The gain and impedance characteristics of the meta-material-backed patch antenna were measured and were found to be in agreement with the values reported by the University of Michigan within the accuracy of our measurement given the gain standards available at ARL and our knowledge of the details of their measurement procedures. The antenna proves to be broadband, both in impedance and antenna pattern characteristics, which promises to be useful for many applications.

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